Salish Sea acidification model – Relative influences of regional sources (water and air) and the Pacific Ocean

EPA Workshop – March 4, 2015

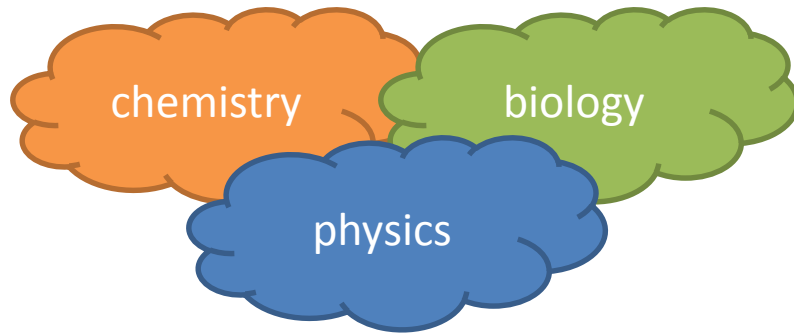Mindy Roberts, Greg Pelletier, Anise Ahmed, and Teizeen Mohamedali (Ecology)

Tarang Khangaonkar, Wen Long, Laura Bianucci (Pacific Northwest National Laboratory)
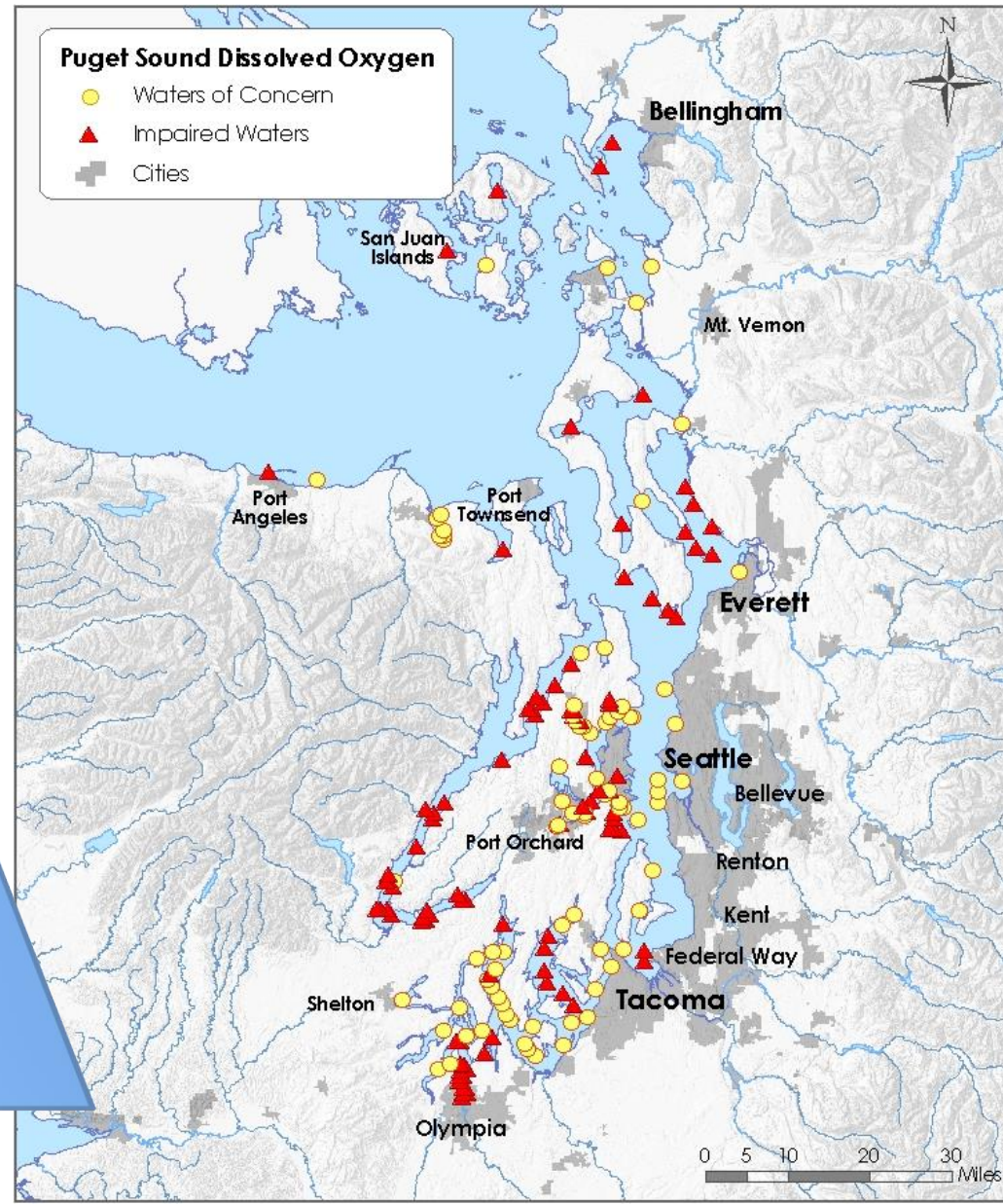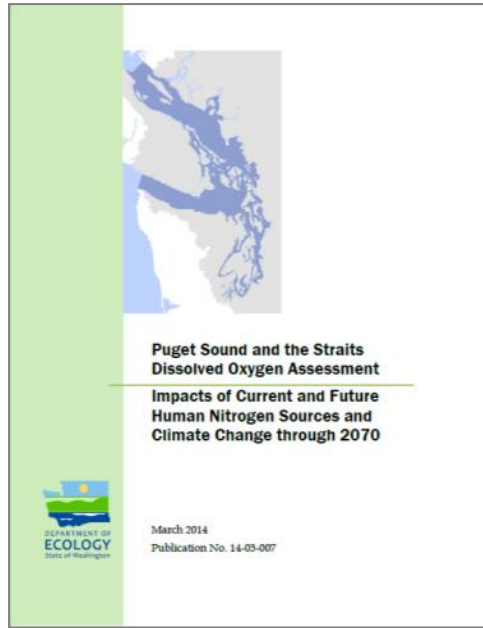
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Many factors influence oxygen... *and pH*

chemistry

biology

physics

Pacific Ocean dissolved oxygen levels, coastal upwelling, Pacific Decadal Oscillation, other climate cycles, NE Pacific oxygen trends, ocean circulation, residence time, estuarine circulation, stratification, vertical mixing, wind, air temperature, organic matter decay, sediment burial rates, trophic-level dynamics, algae growth, water temperature, *human wastewater input, river flows, river nutrient inputs, sediment-water processes, etc. ...*
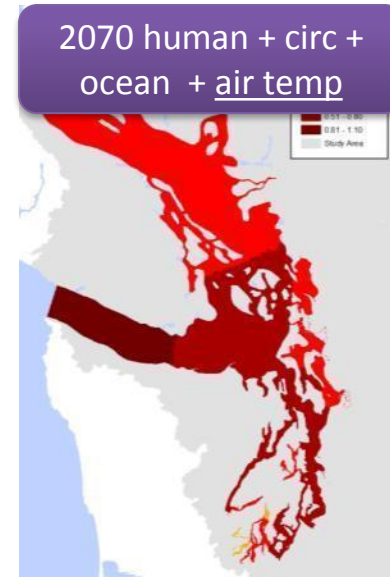
Puget Sound Dissolved Oxygen

○ Waters of Concern

▲ Impaired Waters

▦ Cities

Bellingham

San Juan Islands

Mt. Vernon

Port Angeles

Port Townsend

Everett

Seattle

Bellevue

Port Orchard

Renton

Kent

Federal Way

Shelton
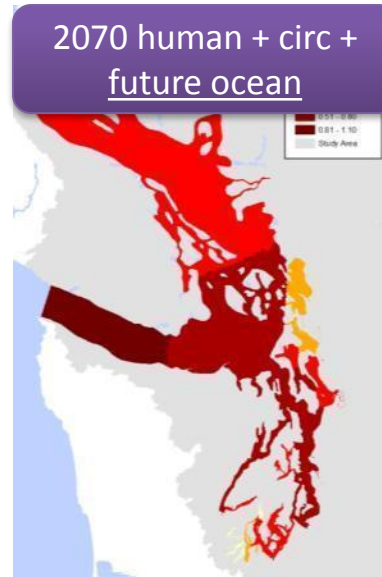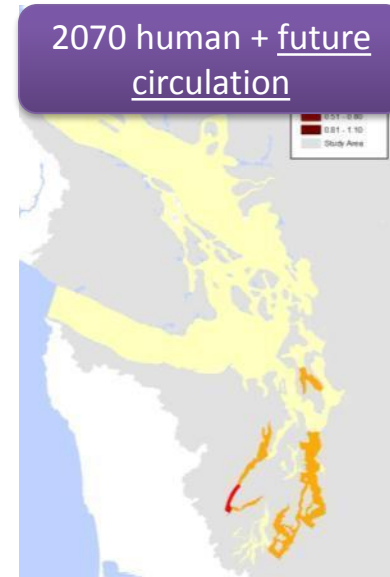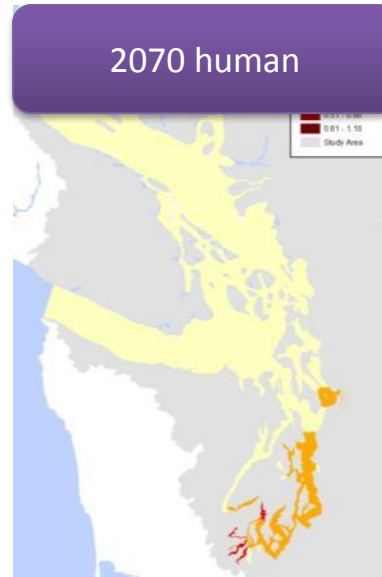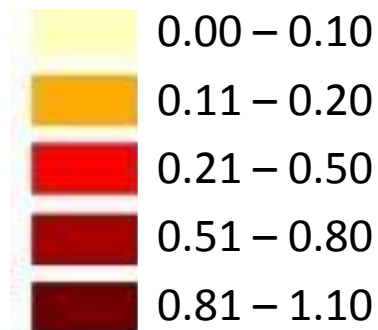
Tacoma

Olympia

0 5 10 20 30 Miles

Future population, land cover, snow pack, Pacific Ocean trends, air temp would collectively worsen oxygen impacts

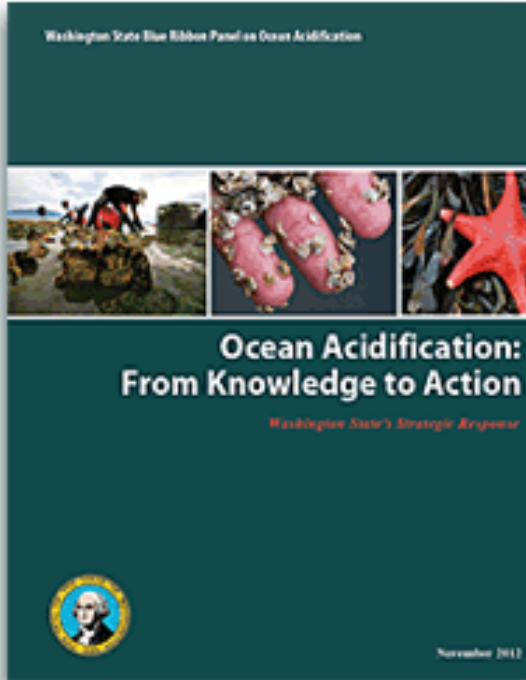**Puget Sound and the Straits Dissolved Oxygen Assessment**

Impacts of Current and Future Human Nitrogen Sources and Climate Change through 2070

ECOLOGY
State of Washington

March 2014
Publication No. 14-03-007

Average depletion

(mg/L of oxygen decline compared with current conditions)

Color	Range
	0.00 – 0.10
	0.11 – 0.20
	0.21 – 0.50
	0.51 – 0.80
	0.81 – 1.10

2070 human

2070 human + future circulation

2070 human + circ + future ocean

2070 human + circ + ocean + air temp

2012 Summary Report

- 17 key early actions including 7.2.1:

    – Quantify key natural and human-influenced processes that contribute to acidification based on estimates of sources, sinks, and transfer rates for carbon and nitrogen

    – *How much is regional? Global atmosphere and Pacific Ocean?*

Quality Assurance Project Plan in review now

Marine dissolved oxygen water quality standards for pH

- 7.0 < pH < 8.5 SU

- *And* **total human-caused variation must be <0.2 or <0.5 SU (varies by location)**
  - ➢ All times of year
  - ➢ Any location
  - ➢ Point + nonpoint sources share

Aquatic Life Use
- Extraordinary (AA)
- Excellent (A)
- Good (B)
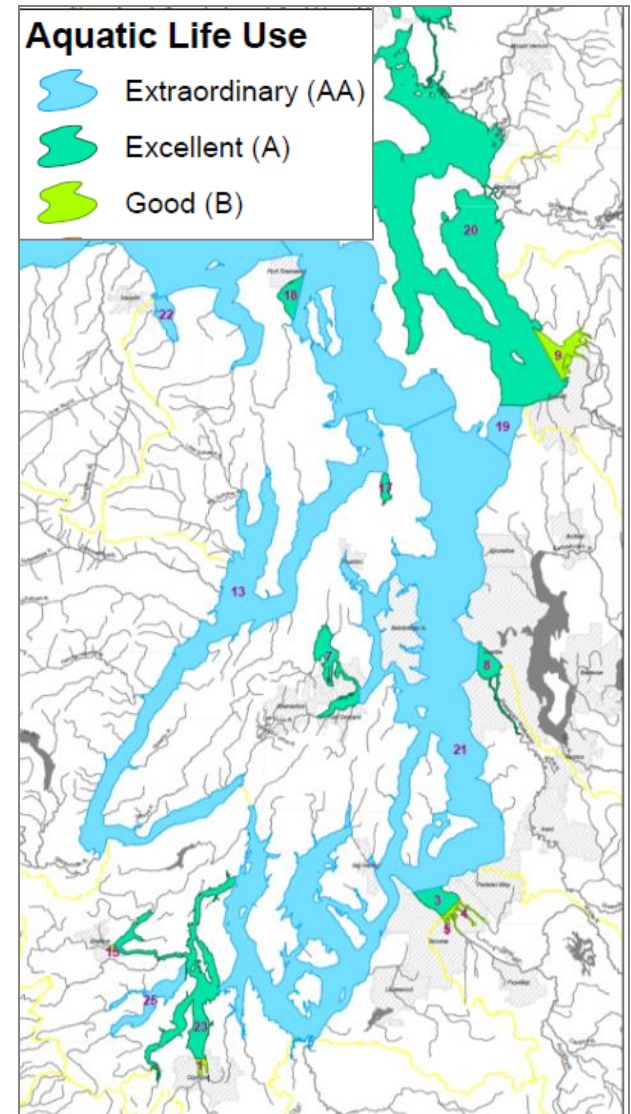
Salish Sea acidification modeling development and application steps

- Quality Assurance Project Plan (now; how?)
  - 2014 model approach document
- Model setup and testing (next)
- Data for boundary conditions (next)
  - Pacific Ocean – current, past, future pH, DIC, alk?
  - Regional human and natural freshwater contributions (marine point sources, rivers) from DO model
  - Regional air influences – pCO2 at Space Needle vs. Washington coastal buoys – rule in/out?

Salish Sea acidification modeling development and application steps

- Calibration – focus on large scales (2015)
  - Marine ambient data for pH being re-evaluated
  - Very few alkalinity or dissolved inorganic carbon
- Initial evaluation of acidification processes – changes in pH, aragonite saturation due to regional or ocean influences? (2016)
  - *Charting new territory…*
  - No standard for aragonite saturation so proposed values to use for model output comparisons

What is the goal?
Relative impacts on pH and aragonite saturation in the Salish Sea, similar to approach on oxygen:

Increased air temperature

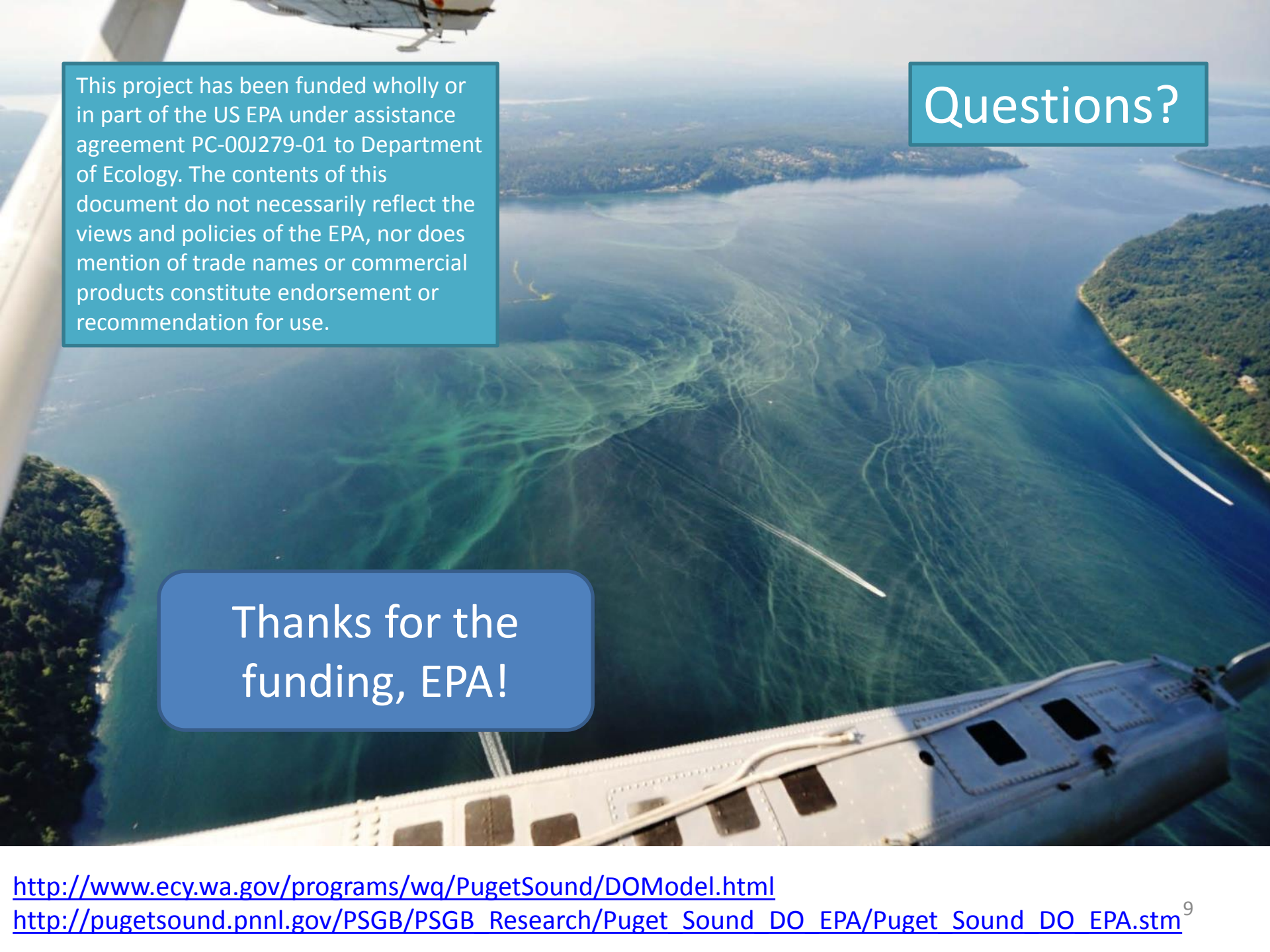**Changes in circulation due to changes in freshwater inflows**

Increased wastewater from future population

Sediment-water exchanges

Pacific Ocean trends

Higher river nitrogen concentrations from land cover change

Questions?

Thanks for the funding, EPA!

http://www.ecy.wa.gov/programs/wq/PugetSound/DOModel.html
http://pugetsound.pnnl.gov/PSGB/PSGB_Research/Puget_Sound_DO_EPA/Puget_Sound_DO_EPA.stm

Influence

HIGHER — LOWER

Uncertainty

HIGHER — LOWER

Future ocean conditions

Future marine community shifts

Future climate
(air temperature, precipitation, hydrology)

Future sediment-water exchanges

Future watershed concentrations
(land cover)

Future watershed inflows

Future marine point source concentrations

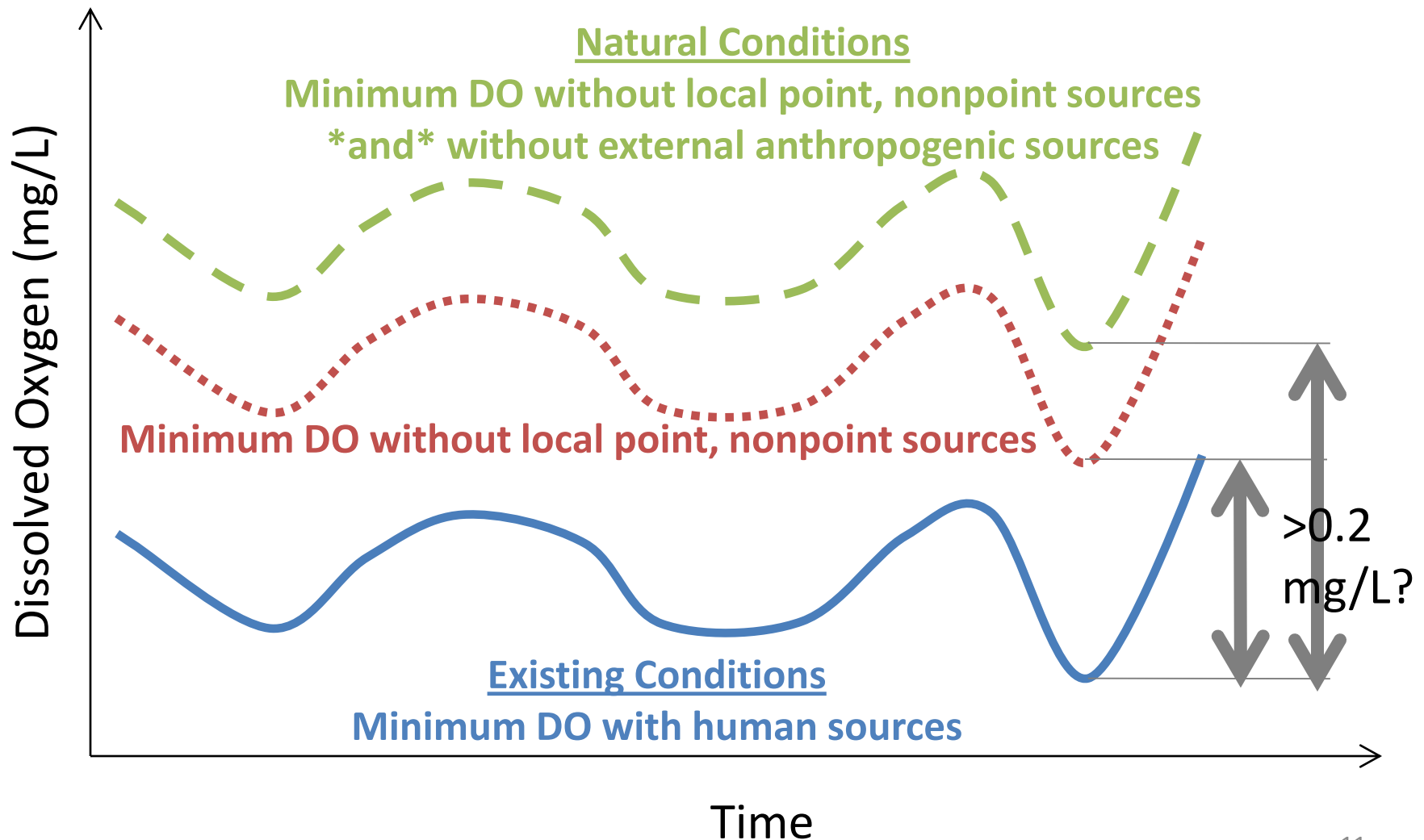Future marine point source flows

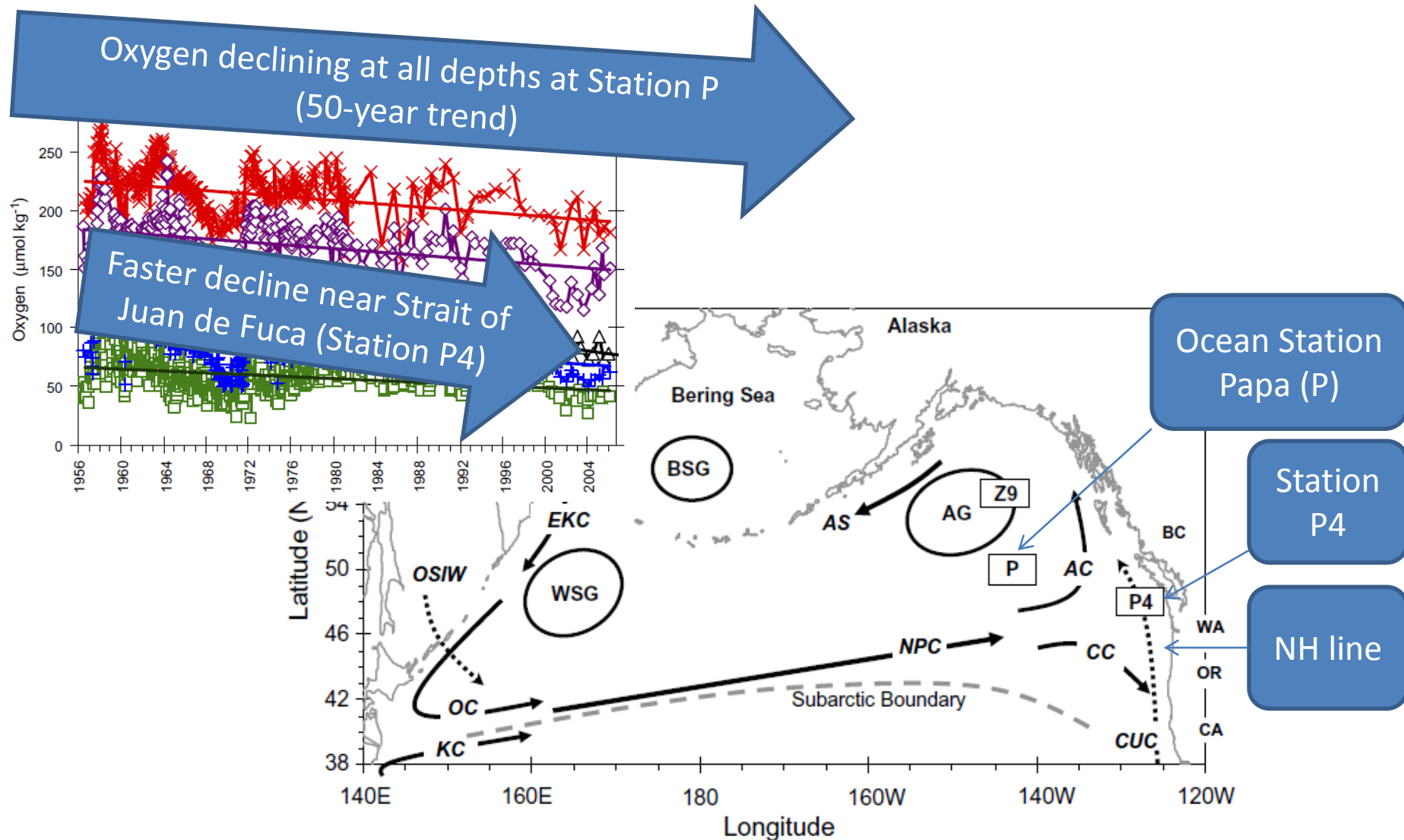*Current sediment-water exchanges*

Current ocean conditions

Current watershed inflows

Current marine point sources

10

Model approaches for applying to water quality standards – example calculation

Dissolved Oxygen (mg/L)

Natural Conditions
Minimum DO without local point, nonpoint sources
***and* without external anthropogenic sources**

Minimum DO without local point, nonpoint sources

Existing Conditions
Minimum DO with human sources

>0.2 mg/L?

Time

Future scenarios – Pacific Ocean trends

Oxygen declining at all depths at Station P (50-year trend)

Faster decline near Strait of Juan de Fuca (Station P4)

Ocean Station Papa (P)

Station P4

NH line

Pacific Ocean modeling from Davis et al. (UC Irvine, Univ. of Washington)
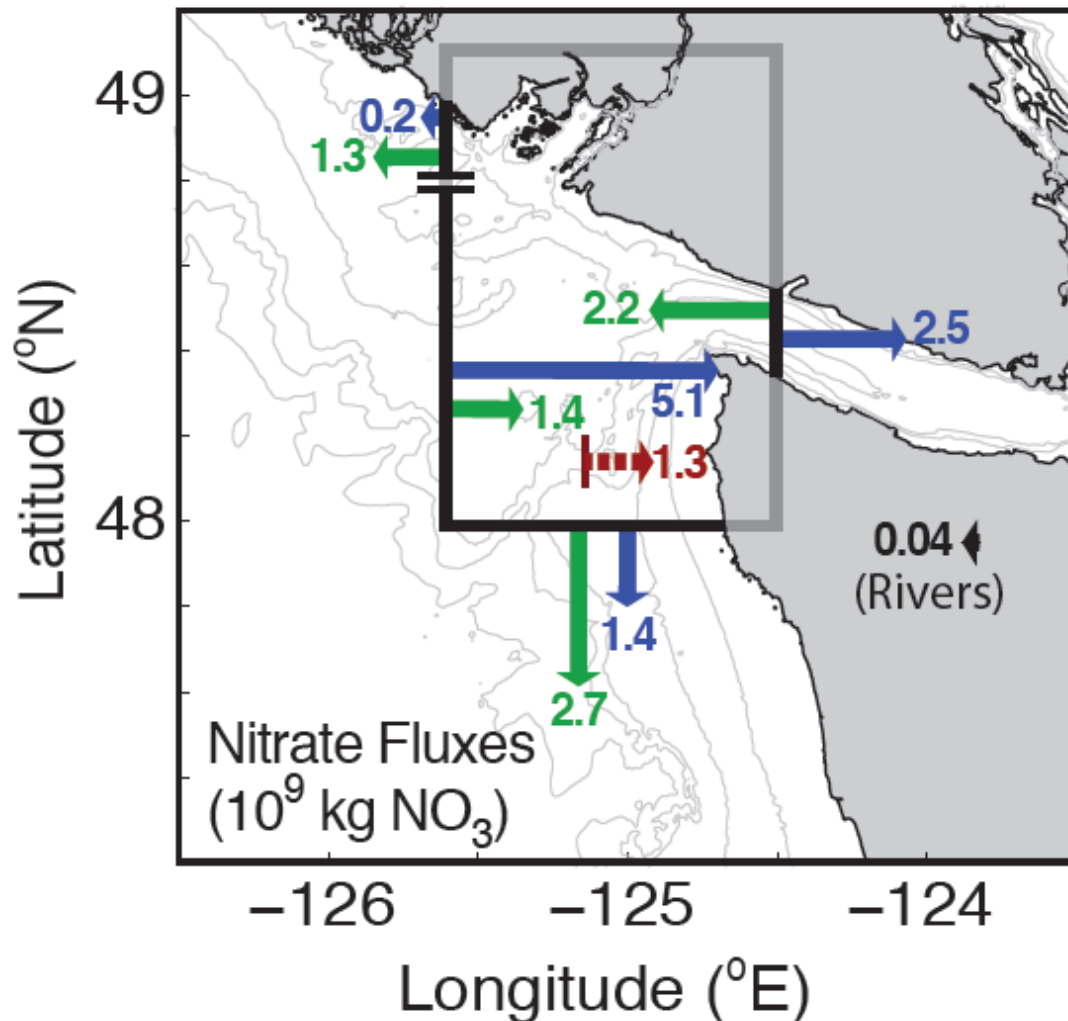
Surface (<50m)

Bottom (>50m)

April – September

Source: Davis, K., N. Banas, S. Giddings, S. Siedlecki, P. MacCready, and B. Hickey (in preparation), Freshwater influence on coastal productivity in the U.S. Pacific Northwest.